An Emergent-Based Approach for Deriving Business/IT Alignment Models and Measures through IS Enactment

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Abstract

Business/IT Alignment is an information systems research field with a long existence and a high number of researchers and represents a central thinking direction over the entanglement between business and information systems. It aims to achieve a paradigm, on which there is a high degree of visibility and availability of information about the information systems sociomateriality. Complex-networks constitute an approach to the study of the emergent properties of complex-systems that strongly focuses and relies on models and measures, through which the system interdependence is built. Several characteristics of complex-networks are: structural or functional topology; domain independent; quantification of elements' relationships; visibility and capture of emergent properties. We introduce a set of models and measures through the dimensions of a profiling framework illustrated with an exploratory case. The introduced models and measures intend to derive information systems effects in Business/IT Alignment.
Keywords: Emergent, Business/IT Alignment, Profiling Framework, Complex-Networks.

1. Introduction

IS scholars are gradually moving away from the traditional static, reductionist view of the entanglement, to conceptual models highlighting the entanglement process as complex. The complexity resulting from the emergent enactment only exists on the whole. To have an entity that describes this emergent enactment as a whole is fundamental. A virtual organization (VO) can describe this coordination of complexity, as well as the interdependent power relationships and decision-making within the emergent enactment entanglement.

In fact, IT alignment to business is best described not as a one dimension phenomenon but as a superset of multiple, simultaneous component entanglements that bring together an organization's structure, strategy, and culture at multiple (IT, business unit, and corporate) levels, with all their inherent demands. It becomes a sociomaterial construction as defined by Orlikowski [17]. It emphasizes principles of interdependence and coevolution where decision-making and business processes are being overhauled to fit better with "networked".

The principles of complex-networks are understood as a theoretical lens and a tool particularly suitable for capturing the emergent enactment as a whole. Instead of reducing a phenomenon to a set of causal variables and an error term, the complex-networks demonstrate how aggregated structures arise from simple representations and interactions of microstate events within a context. The complex-networks allow opportunities for analysing the emergent phenomena without abstracting away the entanglement. Accordingly, are viable for

a more comprehensive and cross-level research in the drive of the information systems sociomaterial coevolution [16].

The work presented in this paper tries to describe some of these properties by (1) providing an profiling framework relevant for extracting information systems enactment models and measures and from them (2) define a comprehensive set of dimensions for deriving the relationships existing among IS elements and then from the models and measures (3) infer about Business/IT Alignment. The proposed approach aims to improve the Business-IT alignment efforts through models and measures of information systems enactment. The rest of the paper is organized as follows. Section 2 motivates the research and outlines the overall research line in which this work is framed. Section 3 proposes a framework for profiling the information systems emergent virtual organization. Section 4 presents the IS enactment data transformation. Section 5 derives the functional models and measures. Section 6 reviews some of the lessons learned. Section 7 draws the conclusions and future works.

2. Motivation

It is not difficult to argue that over the years, information systems research, dedicated a high volume of time and resources to the understanding of the alignment, between the organization and information technology, as a determinant of organizational sustainability [6]. This transformation was so dramatic that Nicolas Carr challenged that "*IT doesn't matter*" [5] and, Davenport assumed that processes would become simple commodities [7]. Moreover, evolving from a long existence of GRID architecture, this transformation commercially consolidated under the Cloud concepts [10]. Technological agency theoretical position assumes that users enact technology in prescribed ways. However, it is observable that "*They can use it minimally, invoke it individually or collaboratively, and improvise in ways that produce novel and unanticipated consequences* [3]*."* This observation advises that is the enactment of information technology that produces shapes, and not simply its existence [9].

The ubiquity and described observations guided information system scholars to argue that information systems organizational determinants (information systems competencies) emerge from enactment in practice [16]. Designer images of enactment are partial since improvised action occurs in practice, taking features for purposes other than initially intended [1]. As enactment occurs in practice, significant organizational changes may result over time. In a social agency perspective, information systems competencies are not only realized from the representation of social process into technology. Rather, "*[...] every engagement with a technology is temporally and contextually provisional, and thus there is, in every use, always the possibility of a different structure* [3]."

VOs are a phenomenon supported by the concepts of ubiquitous information systems [25] and mass collaboration [24]. Entities such as individuals, groups, enterprise units or entire organizations, collaborate to accomplish common goals. A VO represents a linked structure of that infrastructures collaboration. This allows the VO to assume an increasingly prominent function in the context of today's dynamic linking [12].

The information systems competencies [19] are virtual organizations from the practice. Orlikowski defines this phenomenon as the sociomaterial construction of information systems competencies [17]. Functional models facilitate the understanding of the enactment in practice and can represent the emergent virtual organizations of information system structures (competencies). They can destroy or create the conditions for the enterprise architecture to achieve alignment [28, 29].However, capturing and using information systems virtual organizations and the necessary model acquisition approach and dimensions remain challenging. Determined on capturing organization's "***WHAT"***, enterprise architectures provide process-centered, and role-based languages not concerned with *emergence* resulting from the enactment of IT prearranged subjects. *The virtual organization* that performs the work (work system), *when* perform it and "***HOW***" social and IT interact with each other, are not also a concern.

Complex-network analysis can describe significant properties of complex-systems by statistically quantifying and modelling the emergent network topology [11]. Complex-

network concepts are applied on situations from biology to human creations (enterprises), and social interactions [2], in the pursue of answers to questions like: what does the Internet structure and the propagation of HIV infections have in common or how companies evolve. Many aspects of those systems are relevant and worthy to be studied [13]. Some researchers study the individual components while others study the nature of the interactions [13].

However, there is another aspect of the interacting systems, sometimes neglected, but crucial to the understanding of the emergence, which is the anatomy of the connectivity enactment [13]. In this case, the fundamental concern is to discover the anatomy of the structures because patterns always affect the function [23].

3. Profiling Framework

Firstly, from the business domain emerges a functional VO a result of the enactment of the information system structural competencies to address a business goal. This domain outlines the unit of analysis for which has to be gathered the enactment raw data. Secondly, the analytical domain describes the emergent virtual organization or organizations through multidimensionality. This results from the application of the complex-network metrics to the enactment raw data. The raw data through its connectivity must be able to describe the VO sociomateriality construction. Finally, the resulting models and metrics become available for exploitation, as images of the organization, at the model domain.

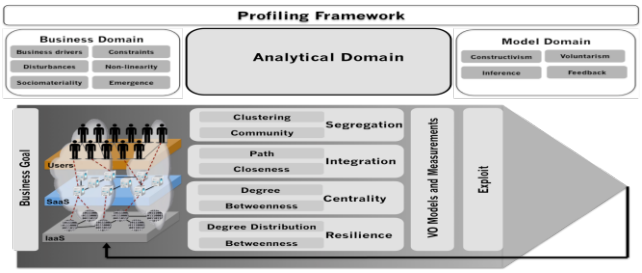


Fig. 1. Information system virtual organization modelling.

In resume, the Profiling Framework (Fig. 1) develops the alignment in a continuous process of three dimensions studied through analytically discovering the emergent "*HOW*" in the raw data representing the enactment as sociomateriality connectivity. Taking into account that, for each top-down structure, there is a subjacent bottom-up emergent course, during its enactment, we can devise a dimension on enactment: the "Business Domain". At the business domain, designers use abstraction techniques to construct the systems.

They focus on processes, integration models, code generation and other techniques in order to realize a system that meets the functionality set by the corresponding business profile. However, the system sociomaterial enactment occurs as a rationalization of information flow through the "HOW". In the enactment rationalization between technological functionalities and users emerges a virtual organization as a representation of that "HOW". The classification of the enactment into categories according to its properties or capabilities is just one of the dimensions concerning the global understanding of the information system emergent virtual organization. A set of functionalities, emergent in the system through sociomaterial enactment of the resources are here named "Virtual organization emergent profile"(VOEP).

The study of the emergent virtual organization aims to develop strongly based models and measurement properties. Such approach allows reduction of semantic gaps, enables higher independence and resilience of domain models from characteristics and changes on VBE and promotes automation of the development tasks, enabling reuse of knowledge relative to either best practice on the enactment or to the organization VBE. They describe the voluntarism and the constructivist nature of the enactment, the possibility of inference and the feedback nature. The exploitation is for Jeanne Ross [21] the most difficult part of

information systems management, but the one that through minor changes produces big results in a process from small data to big impact.

3.1. Measurements of Segregation Model

Segregation is a functional property and describes the extent of the neighbourhood of a given node in the network. It is associated with the emergence resulting from the enactment rationalization and describes the network transitivity capability. The clustering develops in a process that a friend of a friend is also my friend, where if the node u connects to the node v, and v connects to w, then u also connects to w. A high number of such triangles imply segregation. The fraction of triangles around an individual node is known as the clustering coefficient (C) [8], [13].

The clustering (C) is the probability that if a triple of nodes in a network is connected by at least two links, then the third link is also present. Measures of segregation can also find the exact size and composition of individual groups. Subdividing the network into such groups of nodes reveals the complex-network community structure. The community is defined by the appearance of densely connected groups of nodes (patterns or motifs), with only lighter connections between groups (Mark Newman, 2006). When not knowing the structure of an organization and study it by gathering a network through real data, it would be possible to deduce the existence of groups by observing its community structure.

3.2. Measurements of Integration Model

Integration describes the extent to which a given node is apart from others in the network. It describes the flexibility for quickly combine specialization from distributed elements. It relates to decisions made at design and configuration phases, regarding the coupling of systems. Integration metrics description focuses on the complex-network measure of path.

Paths are sequences of distinct nodes and links [8], [13] that define the ease of communication. This complex-network metric represents the potential routes for information flow between pairs of nodes. The paths lengths, therefore, estimate the flexibility for functional integration between elements. Additionally, functional connectivity data already contain such information for all pairs of nodes. They may not correspond to the defined information flow on structural connections. The average shortest-path length (li) (closeness centrality) between all pairs of nodes in the network is known as the characteristic path length of the complex-network [13].

The closeness centrality of a node in a network is the inverse of the average shortest-path distance from the node to any other node in the network. It can be viewed as the efficiency of each node (individual) in flowing information to all other nodes. The larger the closeness centrality of a node, the shorter the average distance from the vertex to any other node, and thus the better positioned the node is in flowing information to other nodes [13], [20]. A long path mainly influences the characteristically path length as short paths mainly influence the global efficiency. This may enable the global efficiency characterization through integration. In networks, visual representations of connection lengths typically are dimensionless and do not represent spatial or metric distance [22].

3.3. Measurements of Centrality Model

Centrality describes the extent to which a given node connects or can connect to others in a network. It relates with power, influence in decision-making and innovation. Key hub nodes often interact with many other nodes, facilitating functional enactment. The degree, k, of a node is the total number of its links [8]. The degree has a straightforward interpretation that is: nodes with a high degree, structurally or functionally actively link, in the complex-network. Then the degree may be a sensitive measure of centrality in complex-networks.

Metrics of centrality focus on the idea that central nodes participate in many short paths within a complex-network topology and consequently acts as important controls of network

flow. A related metric is betweenness centrality, defined as the extent, to which geodesic paths (shortest-paths) in a complex-networks, pass through a given node [13, 14]. It can be used to detect important structural or functional topology through the not measurement of the well connected but the links that fall between.

3.4. Measurements of Resilience Model

Resilience is a property, describing the extent to which a node or link, removal or addiction affects the network. It is the process that transforms the metrics into prediction or conclusion about the overall systems behavior. One of the goals of resilience is to understand how these events, affect the network as a whole. Metrics of resilience quantify features that comprise complex-network vulnerability to removal or change.

The total distribution of nodes degree of an entire network is its characteristic degree distribution [8], [13] and as a central role on the characterization of resilience. Another, suitable metric of resilience is the betweenness centrality. Betweenness measures the influence a node has over the spread of information through the complex-network. Counting only shortest paths definition implicitly assumes that information spreads only along those shortest paths. The efficiency goal is to reduce wiring costs. Direct measures of complex-network resilience test the complex-network before and after a presumed change.

4. Transforming the Data

The functional VO can be modelled and measured using complex-networks through the following four steps (Fig. 2) if from the gathered sociomaterial connectivity raw data is possible to: (1) define the network nodes; (2) define the association between nodes; (3) generate an association matrix by compiling all pairwise associations between nodes to produce a matrix of connectivity and (4) measure and model the network parameters of interest.

The step 1 of Fig. 2 defines the unit of analysis being modelled and measured. In this definition can be used prior structural criteria or functional profile evaluation. It can also be informed from the profiles of the functional connectivity of the different information systems. The functional process is the discovery of the emergent virtual organizations from the structural VBE. The step 2 gathers the corresponding data. This gathering uses the available raw data in the digital logs at the technological systems, in the functional case, and in the design data, in the structural case.

At step 3, occurs the transformation of the gathered data into models and measurements. It is a critical transformation since the resulting data will be used as complex-network input. Different data will produce complex-networks of different topology. In this step the raw data transformation, to ensure the limits and quality of the data follows the KDD [18] process. Finally, at step 4 from the complex-networks models and measurements as images of the enactment is possible to infer and shape the information system alignment ought-to-be.

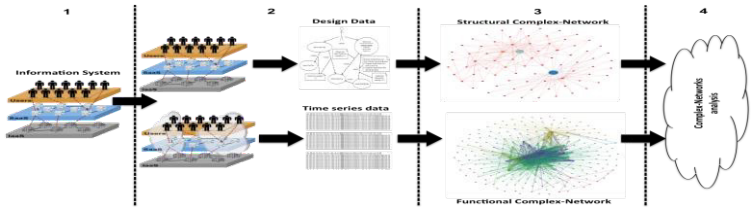


Fig. 2. The Virtual organization complex-networks sourcing process.

The addressed technological artefacts are software-based artefacts such as packages, modules or web applications. The web applications are represented by the web page id that describes the web application functionalities. The enactment of these artefacts occurs at the SaaS level and is constrained by the structural decisions. The connections between packages

and modules or the structure of the web application represent those constraints. The sociomaterial nature of the emergent virtual organization results undirected since technology or users can trigger the enactment and develop the link although the direct nature of the software technology [15]. Moreover, the structural nature of the VBE develops with direct links through expected behavior at the design phase.

5. Deriving the Functional Models and Measures

This paper examines a Web Portal information system as an exploratory case through the presented profiling framework. A process of the exploratory case is illustrated in the Fig. 3.

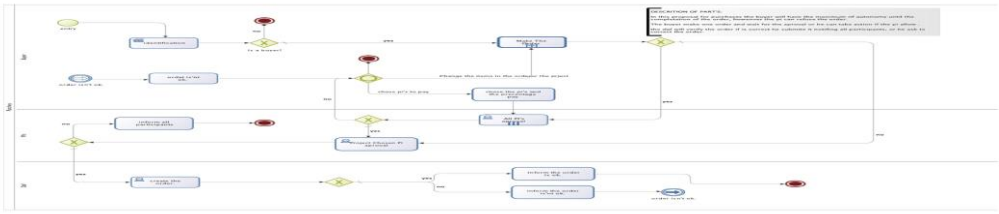


Fig. 3. The Web Portal communities' topology filtered from the global topology.

This analysis starts with the description of the sociomaterial virtual breeding environment (SVBE) as a complex-network. Moreover, focuses in the discovery of the virtual organization emergent profile (VOEP), from the enactment recorded into the Web portal logs raw data. Can the defined profiling framework achieve the Web Portal "HOW" from its technological enactment logs? The process starts through the definition of the SVBE that in this case is the Web Portal enactment defined as an organizational management tool. The enactment is represented into the logs of the Web Portal Http Server and after the data transformation to produce an edge list that represents the enactment as a complex-network, is used as input for the profiling framework. Table 1 illustrates the context.

Table 1. The context of the Web portal network.

Measuring	Measures	Values
Context	Nodes	749
	Links	6636
	Type	Undirected

Table 2. The Web Portal communities' measurements.

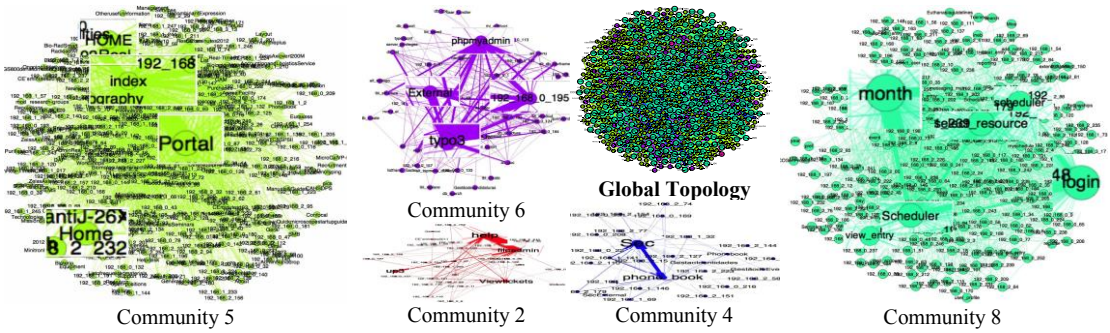
Measuring	Measures	Values
Communities	5	(52.2%)
	8	(31.24%)
	6	(6.81%)
	2	(4.54%)
	4	(3.74%)
	1	(0.67%)
	7	(0.27%)
	3	(0.27%)
	0	(0.27%)

Due to size limitation of this paper it is only described the segregation dimension. Through communities measurement emerged nine communities that are illustrated in the Table 2. Two of the communities, the communities 5 and 8, presented a value of more than 83% of the overall topology, with values of 52,2% and 31,24% respectively. The communities 6, 2 and 4 presented values, 6,81%, 4,54% and 3,74% respectively. The community 1 presented a value of 0,67%. Finally, the communities 7, 3 and 0 presented the same value, 0,27%. Each colour represents a different community to facilitate the overall view of the topology and to make possible the identification of each community more easily. The Table 3 illustrates the Web Portal global topology and five most relevant communities. The topology is zoomed to facilitate the visualization of the nodes. However, in some cases that is not completely achieved.

The community 5 presented stronger links between the nodes, *home, HOME, index and Portal*. The community 8 presented stronger links between the nodes *month*, *select_resource* and *login*. The community 6 presented stronger links between the External, typo3, phpmyadmin and *192_168_0_195*. The community 4 presented in the topology a stronger link

between *Sec* and *Phone_book*. In the Table 3 the community 2 presented a stronger link between the nodes *help*, *fileadmin*, *viewtickets* and *UP3*.

Table 3. The Web Portal communities' topology filtered from the global topology.



6. Lesson Learned

The described emergent virtual organization presented a structure semantically related to the organizations' functional structure. The answer to the first question is then that the profiling framework through the segregation dimension is able to define the emergent virtual organization and in that way characterize the organizational "**HOW**" from the sociomaterial enactment logs. This conclusion is related to other research such as [26, 27], [4], where the communities are able to uncover the emergent dynamics of the sociomateriality.

Additionally, the nodes considered structural for the Web Portal presented the smallest values. This measuring allows the inference that they are nodes that functionally deal with restricted information that does not flow to the other nodes. However, the node index is a special case. By having the smallest value, 1,17, it determines that this node is not able to deal with information flow. It is possible to infer about the alignment when the introduction or removal of an element increases the path and decreases the closeness since they are inverse. The drive of the alignment would represent a decreasing in the average path and an increasing in the closeness centrality. The node phone book is relevant since that it is responsible for managing the active users policies in the Web Portal. This allows the inference that sociomateriality enactment intervention in elements with high betweenness improves the drive of alignment focused on few assets. Moreover, the *Resources* node is responsible for the management of the facilities that a user can use. They need to be subscribed in the Web Portal to be available. The *phpmyadmin* node represents the tool that is used by the administrator to manage the database tables that compose the system. As the interface for those tables it is central in their management.

The profiling framework develops a holistic view of the emergent virtual organization. It shows that sociomateriality enactment is a fully key driver. Focusing that the enactment exploitation is a differentiator enhancement for verification/specification of information system's enactment. Complex-Networks show that it is possible to collect the emergence of sociomaterial enactment. This points the modelling and measuring as a trigger for unique governance exploitation. A main limitation of the present exploratory case is that it does not compare two moments in time where occurred changes in the elements of the Web Portal.

7. Conclusions and Future Work

We are developing that profiling the "HOW" from the emergent virtual organizations that occurred through the sociomaterial enactment can provide the development of an augmented reality exploitation of the information system business alignment. With this augmented reality of the Business/IT Alignment is possible to infer proper approaches that can be used to drive the information systems. Moreover, presents the sociomaterial characteristic that allows the

system to easily evolve or fail. Moreover, on can expect that a progression towards emergent virtual organization modelling and measuring to be suitable.

Complex-networks are described as suitable to be adopted in the study of the information systems emergent virtual organization. A set of four analytical dimensions is described in consonance with the adoption of the complex-network approach. These dimension are used to profile the Business/IT Alignment as an emergent property of the information systems virtual organization. It defines a profiling framework that introduces, integrates and describes the models and measures that sustain the four dimensions relevant to the Business/IT Alignment. This profiling framework is a mechanism to study the emergent virtual organizations resulting from the information systems sociomaterial enactment. Further exploratory cases must be done to accent its contribution for the Business/IT Alignment.

Can the development initiatives of the information systems alignment be more effective as a result of the profiling framework? One could argue that they can because, without knowing the existing information flow, "only" by modelling and measuring the sociomaterial enactment we can trace an image of the organizational entanglement. It is an approach from small data to big impact where the information systems entanglement can change "everything".

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